Flux decrease of outer radiation belt electrons associated with solar wind pressure pulse: A Code coupling simulation of GEMSIS-RB and GEMSIS-GM

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Relativistic electron flux of the outer radiation belt dynamically changes in response to solar wind variations. Enhancement of dynamic pressure causes the flux drop-out of the outer belt electrons, and magnetopause shadowing (MPS) has been proposed to cause rapid loss of relativistic electrons (e.g.,Kim et al.,2008). In general, it has been expected that MPS is a cross-field transportation due to convection and/or the dayside compression of the magnetosphere. However, the gyro-radius of relativistic electrons of the outer belt seems to be too small compared with the spatial scale of gradient of the dayside magnetopause, so that it is difficult for electrons to escape across the magnetopause(e.g., Kim and Lee, 2014). In this study, we investigate another escaping process of relativistic electrons into the interplanetary space. We conduct a code-coupling simulation of a test-particle simulation code (GEMSIS-RB: Saito et al., 2010) and a global MHD magnetosphere simulation code (GEMSIS-GM: Matsumoto et al., 2010). We calculate trajectories of a number of electrons of guiding-center of electrons in electromagnetic fields calculated from GEMSIS-GM. In the simulation, electrons are initially distributed from Re = 6 to 11 with initial energies from 1 MeV to 10 MeV. Initial pitch angles of electrons are distributed from 50 degrees and 90 degrees. In this simulation, the solar wind dynamic pressure and the magnetopause stand-off distance change in the different phase of variation ; [i] The stand-off distance of the magnetopause is 12 RE with the initial dynamic pressure of 1.0 nPa, By_IMF of 0.005 nT, Bz_IMF = 3.0 nT. [ii] The solar wind dynamic pressure increases to 2.5 nPa, and the magnetopause moves to 9 RE. In this period, the pitch angle scattering of electrons with L value larger than 9.0 occurs by Drift Shell Bifurcation (DSB). [iii] The dynamic pressure decreases, and the inflation of the magnetopause takes place. The stand-off distance of the magnetopause moves back to 10 RE. In this period, the pitch angle of electrons with L value larger than 9.25 are scattered by DSB. During phase [ii], the high-latitude magnetic reconnections occur at dawn-side. Several electrons scattered by DSB change their mirror points to the high latitude where electrons can escape into the interplanetary magnetic field along the field line. During the periods, the high-latitude reconnections occur at the high-latitude in the dusk side. As a result, some of trapped electrons escape into the interplanetary space along open magnetic field, which cause the loss of trapped electrons in the lower L-shells at least L = 8.75. In our study, it is also found that outward transport tends to occur at high energy, because electrons with fast drift velocity observes dawn to dusk electric field for relatively long period, and resultant outward movement takes place. Moreover, the higher the dynamic pressure, the lower the L value closer to the earth. The study reveals a part of erectrons of the outer radiation belt escape into the interplanetary space along the field line, which are different process from the MPS.

Keywords: radiation belt, simulation

